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## Quantification of Aquatic Interventions in Children With Disabilities: A Systematic Literature Review

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# Quantification of Aquatic Interventions in Children With Disabilities: A Systematic Literature Review

**Baiba Kārkliņa, Marlies Declerck, and Daniel J. Daly**

The objective of the current study was to quantify and summarize the various aquatic interventions in children with disabilities, including studies of all levels of evidence. Forty-five intervention studies were included and were described within nine disability groups. The largest number of articles was found in the groups of “diseases and disabilities of the nervous system” ( $N = 15$ ) and “mental and behavioral disorders” ( $N = 15$ ). Swimming or aquatic interventions in children with sensory system and integration deficits, circulatory system problems, congenital malformations, and chromosomal abnormalities did not reveal any published literature. The categorization of aquatic interventions was difficult due to several concerns: the lack of common definitions, the absence of intervention details, individualized therapy or training plans without a decision-making model, different types of pools (temperature and depth), and an undefined mix of several intervention types. Training intensity was missing in 68% of the interventions.

**Keywords:** aquatics, swimming, adapted aquatics, disabilities, intervention, children

Physical principles of water such as density, hydrostatic pressure, buoyancy, viscosity, and thermodynamics are used in medical and recreational applications for different populations (Becker, 2009), including children (Dumas & Francesconi, 2001; Geytenbeek, 2008). Water is a special medium and sometimes the only environment where even the most severely affected individuals are able to move and practice active movement that cannot be done on land. Moreover, games and exercises in water and swimming are enjoyable and fun for most.

These medical and recreational applications have been given various labels such as swimming, aquatic exercise, and other different concepts (e.g., Halliwick; Becker & Cole, 2011; Brody & Geigle, 2009), and they are usually used as a component or supplement to other activities (Epps et al., 2005; Johnson, 2009; McManus & Kotelchuck, 2007; Skoffer & Foldspang, 2008). Although, from 2000–2011, a number

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The contribution of the first two authors should be considered as equivalent.

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of literature reviews were conducted in aquatics for children with most focused on specific disability groups, for example, children with neuromotor impairments or cerebral palsy (Blohm, 2011; Getz, Hutzler, & Vermeer, 2006a). One review including various disability groups dates from 2001 (Dumas & Francesconi); it summarized available literature on aquatic therapy for children and adolescents with neuromuscular and musculoskeletal diagnoses using a narrative report of 16 articles. Later the Aquatic Physiotherapy Evidence-Based Guide (Geytenbeek, 2008) concentrated mostly on adults and therapeutic interventions. One chapter was related to pediatrics, including several diagnoses, but some groups were missing: cardiopulmonary, endocrine, metabolic, and sensory system integration disorders. None of these reviews focused on the intervention details or provided a schematic overview of the interventions used.

To collect information on best clinical practice, a review of existing research of all levels of evidence is necessary. The present review will focus specifically on the intervention programs and will attempt to create a schematic overview. The goal is to inform aquatic therapy specialists and other professionals on the potential aquatic interventions within each population and their practicality. For researchers, it will provide an overview of existing literature and missing knowledge.

The research question is what evidence is available on aquatic and swimming interventions for children with disabilities, with the purpose of this study to quantify and summarize the various aquatic interventions in children with disabilities, including research of all levels of evidence.

## Method

### Literature Search

The electronic search included following databases: Cochrane, ERIC, PEDro, Pubmed, ScienceDirect, Web of Science, and HighWire. Several search terms were used; these terms included the following: hydrotherapy, aquatic therapy, water exercise, aquatics, adapted aquatics, aquatic exercise, swimming, Halliwick, Watsu, Ai chi, and Bad Ragaz Ring Method. Inclusion criteria included the following:

- Studies including children and adolescents (ages 0–21) with a disability
- Aquatic or swimming intervention
- Publication dates between January 2000–July 2012
- All types of study designs were incorporated.

Exclusion criteria included the following:

- Swimming or aquatics as an intervention for healthy populations
- Children with a temporary respiratory illness
- Policy statements without an actual intervention

Two reviewers searched the literature independently and assessed whether the research articles met the inclusion criteria. Any discrepancies were resolved through consultation with a third reviewer. The search was limited to English language

Table 1 Quantification of Study Designs

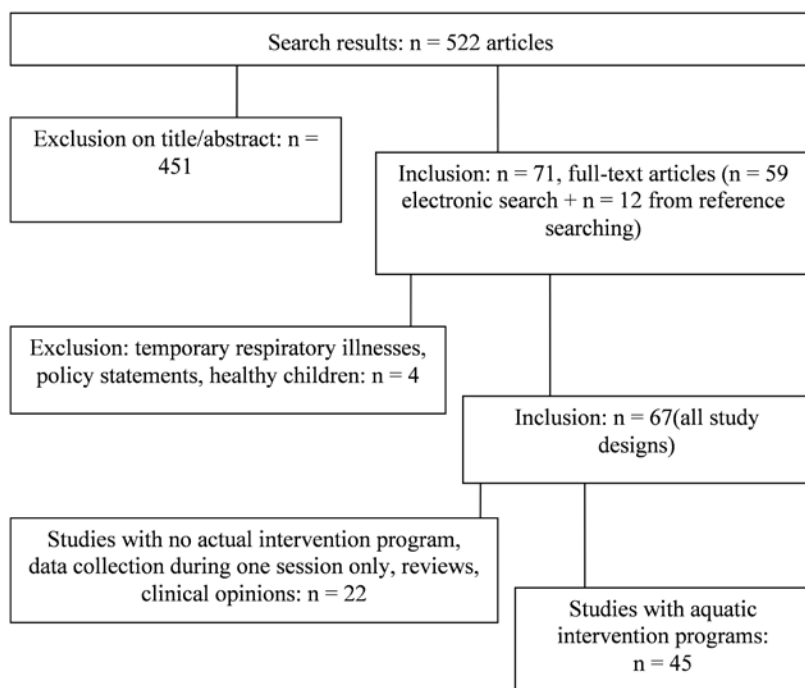
	Disability Group	Intervention Studies	RCTs	nonRCTs	Case-Control	Before-After	Case Series	Case Study
1	Diseases and disabilities of the nervous system	15	3	3	0	4	2	3
2	Diseases of the respiratory system	5	4	0	0	1	0	0
3	Diseases of the circulatory system	0	0	0	0	0	0	0
4	Diseases and disabilities of the musculoskeletal system	3	2	0	0	1	0	0
5	Mental and behavioral disorders	15	2	4	0	4	3	2
6	Endocrine, nutrition, and metabolic diseases	3	0	1	1	1	0	0
7	Sensory system/integration deficits	0	0	0	0	0	0	0
8	Congenital malformations, deformities, and chromosomal abnormalities.	0	0	0	0	0	0	0
9	Mixed disabilities group	4	0	1	0	2	1	0
	<b>TOTAL</b>	<b>45</b>	<b>11</b>	<b>9</b>	<b>1</b>	<b>13</b>	<b>6</b>	<b>5</b>
	%	100	24	20	2	29	14	11

papers. In addition, a reference list search of relevant articles was applied. The steps of the literature search are given in Figure 1.

## Data Evaluation

For the current review, the population was divided into various disability groups:

- (1) diseases and disabilities of the nervous system (“Neuro”)
- (2) diseases of the respiratory system (“Resp”)
- (3) diseases of the circulatory system (“Circulatory”)
- (4) diseases and disabilities of the musculoskeletal system and connective tissue (“Musculo”)
- (5) mental and behavioral disorders (“Mental”)
- (6) endocrine, nutritional, and metabolic diseases (“Metabolic”)
- (7) sensory system and integration deficits (“Sensory”)
- (8) congenital malformations, deformations, and chromosomal abnormalities (“Congenital”)
- (9) mixed disabilities group (“Mixed”)



**Figure 1** — Flowchart of the literature search and selection process.

This division was done according to the International Statistical Classification of Diseases and Health Related Problems 10th revision (World Health Organization, 2010). The Mixed group incorporated studies that included several populations in one study.

The study designs were identified according to the algorithm from The National Institute for Health and Clinical Excellence recommended by Scottish Intercollegiate Guidelines Network (2008). Each article was allocated a level of evidence (Siebes, Wijnroks, & Vermeer, 2002). Randomized controlled trials (RCTs) and non-RCTs were marked as level I and II accordingly; case studies with control participants were marked as level III; and before-after studies, case series, and case reports were marked as level IV and V.

We summarized the intervention details within each disability group. Attempts were made to display a schematic overview of the existing research in the topic.

## Results

In total, 45 out of the 522 research papers identified after search met the inclusion criteria. Search terms that contained “Ai-chi,” “Bad Ragaz Ring Method,” and “Watsu” did not reveal any results.

Table 1 shows the number of studies identified in each of nine disability groups and the study designs. For the Circulatory, Sensory, and Congenital groups, no research papers were found. However, some disorders from these groups (e.g., legally blind, chromosomal anomaly, oto-palatal-digital syndrome, Prader-Willi syndrome, Down syndrome) were present in other studies, included in the Mixed group (Fragala-Pinkham, Dumas, Barlow, & Pasternak, 2009; Fragala-Pinkham, Haley, & O’Neil, 2008; Fragala-Pinkham, O’Neil, & Haley, 2010; McManus & Kotelchuck, 2007). The Mental and Neuro groups showed the largest number of intervention studies, although most had lower levels of evidence (Table 1). Eleven RCTs were available for all groups together.

Categorization of the interventions (Table 2) included 11 categories of which six were reported as the main intervention; these six were the following:

- Halliwick Concept (International Halliwick Association (IHA) Education and Research Committee, 2010)
- Aquatic Physiotherapy
- Swimming
- Exercises in Water
- Walking in Water
- Games/Play Activities in Water

Complementary categories (in the water) were adding Songs or Music; Breathing Exercises; Stretching; and Relaxation.

The Halliwick Concept was used in both the Neuro ( $N = 5$ ) and the Mental ( $N = 4$ ) group. Swimming was the main intervention in 18 of the 27 studies using this intervention, over all groups. Exercises in the water were reported in 28 studies (main intervention in 18), spread over all groups, except the Metabolic group.

Often Swimming and exercises in the water were combined ( $N = 20$ ). Games/play were mainly used as a component of the program and were the main intervention in four studies in the Mental group. Songs or music were added to the intervention in three publications of the Neuro group. Eleven studies explicitly stated that breathing exercises were added to the program and this in the Neuro, Resp, and Mental groups. Stretching and relaxation were added in 13 studies of the Neuro, Musculo, and Mixed groups, and two studies of the Neuro group, respectively. Eleven studies (over all groups) added a land-based component to the aquatic intervention. As can be seen from Table 2, most of the studies included three or more intervention categories. The proportional contribution of each component was however, not always stated. Although most of the aquatic programs were developed on an individual basis (see Tables 3a to 8), almost none of the programs presented a decision-making model defining the program.

## Details for Each Group

Table 2 summarizes all types of interventions used within each research paper. Main contents of the intervention programs are highlighted and described below. Tables 3 to 8 display the intervention details for each group. Unfortunately, 6 of the 45 intervention studies did not report any details of the intervention program.

1. **Diseases and Disabilities of the Nervous System ( $N = 15$ ).** Six articles had evidence levels I and II, but more than half of the articles were levels IV and V. The number of participants ranged from 1–27, with ages ranging from 1–21 years. Youth with cerebral palsy were included in 13 articles.

*Intervention programs (Table 3a, 3b, 3c):* The three RCTs focused on swimming as the intervention (Chrysagis, Douka, Nikopoulos, Apostolopoulou, & Koutsouki, 2009; Dimitrijević et al., 2012; Özer et al., 2007). In five studies exercises in water was the main content of the program (Ballaz, Plamondon, & Lemay, 2011; Kelly, Darrah, Sobsey, & Legg, 2009; Retarekar, Fragala-Pinkham, & Townsend, 2009; Salem & Gropack, 2010; Thorpe, Reilly, & Case, 2005). The Halliwick Concept was used in five publications (Aleksandrovic et al., 2010; Getz, Hutzler, Vermeer, & Yarom, 2006b; Getz, Hutzler, & Vermeer, 2007; Jorgić et al., 2012). Duration of the programs ranged from 6–16 weeks, 2–3 times a week, and 30–60 min per session. The total duration of the intervention program was an average of 1,166 min with a range of 540–2,160 min. Swimming pool description, according to type, was reported in 10 articles.

2. **Diseases of the Respiratory System ( $N = 5$ ).** Four of these intervention studies were RCTs (Tables 1 and 4). A total of 160 participants were used ( $N = 8–61$ ) with ages ranging from 7–22 years. All studied youth with asthma.

*Intervention programs (Table 4):* Two main aquatic intervention types were observed: a swimming program (Wang & Hung, 2009; M. Weisgerber et al., 2008; M.C. Weisgerber, Guill, Weisgerber, & Butler, 2003; Wicher et al., 2010) and an aquatic exercise training program (Hildenbrand, Nordio, Freson, & Becker, 2010) with a duration ranging from 5–12 weeks, 2–3 times a week, and 30–60 min per session. Total duration of the intervention program was average 1,161 min and ranged from 495 to 1,620 min. All of the interventions included breathing exercises. Swimming pool description was reported in two

Table 2 All Intervention Contents as Reported in the Articles

Nr	Disability group	Intervention contents Article	Halliwick Concept	Aquatic physiotherapy	Swimming (exercises and techniques)	Exercises in water	Walking activities in water	Games/play activities (in water)	Exercises, games out of the pool	Adding songs or music	Breathing exercises	Stretching	Relaxation	Intervention details N/R
1	Diseases and disabilities of the nervous system	Dimitrijević et al., 2012			x	x	x	x			x			
2		Getz et al., 2012	x					x		x				
3		Jorgić et al., 2012	x		x			x						
4		Ballaz et.al., 2011			x	x		x					x	
5		Aleksandrović et al., 2010	x		x									x
6		Salem & Gropack, 2010				x	x	x			x	x	x	
7		Chrysagis et al., 2009			x		x					x		
8		Kelly et al., 2009				x	x	x			x	x	x	
9		Retarekar et al., 2009			x	x	x	x				x		
10		Aidar et al., 2007												x
11		Getz et al., 2007	x					x		x				
12		Ozer et al., 2007			x	x		x	x			x		
13		Getz et al., 2006b						x		x				
14		Figuers, 2005		x										
15		Thorpe et al., 2005				x	x	x	x		x	x		

(continued)



Table 2 (continued)

Nr	Disability group	Intervention contents	Article	Halliwick Concept	Aquatic physiotherapy	Swimming (exercises and techniques)	Exercises in water	Walking activities in water	Games/play activities (in water)	Exercises, games out of the pool	Adding songs or music	Breathing exercises	Stretching	Relaxation	Intervention details N/R
16	Respiratory system		Hildenbrand et al., 2010									x			
17			Wicher et al., 2010			x				x		x			
18			Wang & Hung, 2009			x						x			
19			Weisgerber et al., 2008			x		x				x			
20			Weisgerber et al., 2003			x						x			
21	Musculoskeletal system and connective tissue		Epps et al., 2005				x		x	x			x		
22			Takken et al., 2003			x	x	x	x				x		
23			Takken et al., 2001			x	x	x	x				x		
24	Mental and behavioral disorders		Chu& Pan, 2012	x											x
25			Casey et al., 2010			x									
26			Ennis, 2011			x	x	x	x			x			
27			Fragala-Pinkham et al., 2011			x	x	x	x	x			x		
28			Oh et al., 2011			x									
29			Pan, 2011			x	x		x	x					
30			Hillier et al., 2010	x	x		x	x	x	x					

(continued)

Table 2 (continued)

Nr	Disability group	Intervention contents	Article	Halliwick Concept	Aquatic physiotherapy	Swimming (exercises and techniques)	Exercises in water	Walking activities in water	Games/play activities (in water)	Exercises, games out of the pool	Adding songs or music	Breathing exercises	Stretching	Relaxation	Intervention details N/R
31			Pan, 2010			x	x		x	x		x			
32			Rogers et al., 2010			x	x		x						
33			Yilmaz et al., 2010a	x				x	x						
34			Yilmaz et al., 2010b						x						
35			Yilmaz et al., 2009			x	x								
36			Yilmaz et al., 2005						x						
37			Yilmaz et al., 2004	x											
38			Bumin et al., 2003	x											
39	Endocrine, nutritional, and		Sideravičiūtė et al., 2006			x	x								x
40	metabolic		Ildikó et al., 2007			x			x	x					x
41			Klijn et al., 2007			x	x		x	x					x
42	Mixed disabilities		Fragala-Pinkham et al., 2010			x	x		x				x		
43			Fragala-Pinkham et al., 2009		x	x	x	x	x	x			x		
44			Fragala-Pinkham et al., 2008			x	x		x				x		
45			McManus and Kotelchuck, 2007				x		x	x					
X			= main contents of the studies; N/R = Not reported												

Table 3a Diseases and Disabilities of the Nervous System With Intervention Details

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Özer et al., 2007. Turkey	RCT	N = 23 (n = 10 con. gr.). CP	5–10	Swimming training program	Individual, 1:1 (specialized swimming teachers) • first 2 wks: static drills, stretching ex., ball games outside the pool • following wks - drills and ex. in the water • 4th week - The Aquatics Sports Skills Program • not eliciting abnormal patterns of the students (i.e. scissoring of the legs), self-paced swimming style	• 14 wk • 3x/wk • 30 min (gradually ↑ 60 min)	N/R	N/R
Chrysagis et al., 2009. Greece	RCT	N = 12 (n = 6 con. gr.). CP	13–20	Swimming program	2:12 (2 physical educators) • w/u 10 min – main part 35 min – c/d 5 min • walking in shallow pool end, static stretching for the extremities - backstroke, crawl - free swimming, stretching. Individualized progr.	• 10 wk • 2x/wk • 45 min (within school)	N/R	• Indoor • 25 m • 28–31°C
Dimitrijević et al., 2012. Serbia	RCT	N = 27 (n = 13 con. gr.). CP	9–14	Swimming (swimming techniques)	Individual, 1:1 (swimming instructors) • w/u 10 min – swimming techniques ex. 40 min - play 5 min • forward, backward walking, jumping, other ex. - gliding from the wall, floating (prone, back), bubbles, breaststroke, backstroke or freestyle techniques, diving – ball games, chasing games, etc.	• 6 wk • 2x/wk • 55 min	N/R	• Sports center pool • 10 × 30 m • 0.7 & 1.8 m • 27.7°C

(continued)

Table 3a (continued)

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Getz, Hutzler, & Vermeer, 2012. Israel	Non-RCT (pilot)	N = 11 (n = 5 con.gr.) CP	3–6	Aquatics program (Halliwick 10 point concept)	Individual, 1:1 (trained instructors) • w/u 5min – main part 20 min – c/d 5 min • structured group activity, songs - individual/in pairs, 10-point program of the Halliwick Concept - group activities, songs	• 16 wk (4 mo) • 2x/wk • 30 min	N/R	• Indoor • Heated therapeutic swim.pool • 33–34°C
Getz, Hutzler, & Vermeer, 2007. Israel	Non-RCT	N = 22 (n = 10 con.gr.) CP	3–6	Aquatics program (Halliwick 10-point concept)	Individual, 1:1 (trained instructors) • w/u 5 min – main part 20 min – c/d 5 min • structured group activity, songs - individual/in pairs, 10-point program of the Halliwick Concept - group activities, songs	• 16 wk • 2x/wk • 30 min	N/R	N/R
Getz, Hutzler, & Vermeer, 2006b. Israel	Non-RCT	N = 14 (n = 5 con.gr.) neuromotor imp.	3–6	Aquatics program (Halliwick 10 point concept)	Individual, 1:1 (trained instructors) • w/u 5min – main part 20 min – c/d 5 min • structured group activity, songs - individual/in pairs, 10-point program of the Halliwick Concept - group activities, songs	• 16 wk (4mo) • 2x/wk • 30 min	N/R	N/R
Jorgić et al., 2012. Serbia	Before-after study (pilot)	N = 7 spastic CP	7–11	Swimming training (including Halliwick method)	Individual, 1:1 (instructors) • the application of the Halliwick Concept • ex. for swim technique (freestyle, backstroke, and breaststroke) • increasingly more ex. for the realization of the basic Halliwick movement, freestyle, breaststroke, and backstroke technique	• 6 wk • 2x/wk • 45 min	N/R	• Clinical center • N/R

N = sample size (participants that completed study); P = pathology; CP = cerebral palsy; imp. = impairment; ex. = exercise; w/u = warm up; c/d = cool down; N/R = not reported

Table 3b Diseases and Disabilities of the Nervous System With Intervention Details

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Ballaz, Plamondon, & Lemay, 2011. Canada	Before-after study	N = 10 CP	14–21	Group aquatic training program	Group (supervised by 3 physiotherapists and 1 sports teacher) • w/u 10 min – main p.15min - relaxation 5min – play activity 15 min • cervical, limb ex. - relay race deep end – relax - water polo, volleyball (activities changed every second week)	• 10 wk • 2x/wk • 45 min (20 sessions)	Mild to moderate for > 1/2 of the training sess.	• N/R • 31–32°C
Aleksandrović et al., 2010	Before-after study	N = 7 neuro-muscular imp.	5–13	Adapted aquatics	Mainly individual, 1:1 (instructors) • principles of Halliwick Concept, hydro-therapy, nonswimmers training for healthy population. Adapted to age and type of disability • aim: functional independence in the water	• 8 wk • 2x/wk • 45 min	N/R	N/R
Aidar et al., 2007. Brazil	Before-after study	N = 21 CP	6–12	Aquatic activities	N/R	• 16 wk • 2x/wk • 45 min (max)	N/R	• 25 × 12.5 m • Medium depth 1.5 m • N/R

(continued)

Table 3b (continued)

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Kelly et al., 2009, Canada	Case series	N = 5 CP	9–11	Community-based group aquatic exercise program	Group, 3:5 (1 pediatric PT, 2 assistants)	• 12 wk	OMNI score	• Community
					• w/u - aerobic ex. – game context 10 min – c/d	• 3x/wk	(perceived exertion)	• N/R
					• shallow water aerobics, swimming, water walking ex. - water running, jumping jacks, lengths of kicking in circuit, races, aerobics, games - tag, obstacle courses, walking races, etc. – breathing, bubble blowing, self-stretches	• 60 min	5 to 7	
Thorpe, Reilly, & Case, 2005, USA	Case series	N = 7 CP	7–13	Individualized aquatic exercise sessions	Individual, 1:1 (trainers, instructed by PT)	• 10 wk	N/R	• Therapeutic/hospital
					• w/u 15 min – main part 20min – game activities 10–15min.	• 3x/wk		• Depth: 2’–4.5’ (0.6–1.4 m)
					• trunk, lower extremity stretching ex., assistance for stabilizing - strengthening ex. 10–15 reps bilaterally, lower extremity resistive ex.- walking, deep water running, treading water, game activities for strength and endurance	• 45 min		• 32.7°C (91°F)
Salem & Groppack, 2010, USA	Case study	N = 1 type III SMA	3	Aquatic therapy program	Individual, 1:1 (experienced pediatric PT)	• 14 wk	N/R	• Therapeutic
					• w/u - main part – c/d 5 min	• 2x/wk		• 8’ × 12’ (2.4 × 3.7 m)
					• breathing ex., flexibility, walking - balance, posture, strength, functional mobility ex., games, dancing activities, races, aerobic ex.- transitions, breathing ex. with a 3-min break in the middle of the session	• 45 min		• 33°C

N = sample size (participants that completed study); P = pathology; CP = cerebral palsy; SMA = spinal muscular atrophy; PT = physical therapist; N/R = not reported; ex. = exercise; w/u = warm up; c/d = cool down

Table 3c Diseases and Disabilities of the Nervous System With Intervention details

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Retarekar, Fragala-Pinkham, & Townsend, 2009, USA	Case study	N = 1 CP	5	Aquatic aerobic exercise program	Individual, 1:1 (PT) <ul style="list-style-type: none"><li>• w/u (5min, 50-60% intensity) – main part (30–40min, 70–80% intensity) – c/d (5 min, 50–60% intensity)</li><li>• treadmill walking, kicking, stepping - aerobic ex. (+shuttle, jumping, deep water running, creeping, swimming + assistance or flotation device) - walking, leg ex., stretching. Emphasize large muscle groups; fun</li></ul>	<ul style="list-style-type: none"><li>• 12 wk</li><li>• 3x/wk</li><li>• 45 min (34 sessions in total)</li></ul>	<ul style="list-style-type: none"><li>• 50–80% of HR reserve, 135–165 b/pm</li></ul>	<ul style="list-style-type: none"><li>• Hospital pool</li><li>• 8' x 12' (2.4 x 3.7 m)</li><li>• 30–32.2°C (86–90°F)</li></ul>
Figuers, 2005, USA	Case study	N = 1 type I SMA	1	Aquatics	Individual, 1:1 (PT) <ul style="list-style-type: none"><li>• gradual immersion</li><li>• active ROM (flutter kicking: supported), reaching with UL</li><li>• shoulder girdle movement (trunk and head control by the therapist)</li><li>• breathing against the resistance of the water, blowing ping pong balls</li></ul>	N/R	N/R	<ul style="list-style-type: none"><li>• Therapeutic</li><li>• 32.2°C (90°F)</li></ul>

N = sample size (participants that completed study); P = pathology; PT = physical therapist; N/R = not reported; UL = upper limb; ex. = exercise; w/u = warm up; c/d = cool down; SMA = spinal muscular atrophy

Table 4 Diseases of the Respiratory System With Intervention Details

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Wicher et al., 2010. Brazil	RCT	N = 61 (n = 31 con.gr.) MPAA (Asthma)	7–18	Swimming	N/R • w/u 15 min (land) – training in pool • light stretching ex., global postural ex., awareness of diaphragmatic breathing (lying on mats) • pool training: level I – adaptation to the water environment, total immersion breathing, floating/treading water; moving underwater, elementary diving; level II - learning the front crawl and back-stroke (before ex., PEF measurement)	• 12 wk (3 months) • 2x/wk • 60 min	N/R	N/R
Wang & Hung, 2009. Taiwan	RCT	N = 30 (n = 15 con.gr.) Asthma	9–11	Swimming training program	N/R (supervised by certified swimming instructors) • w/u 10 min – main part 30 min – c/d 10 min • breathing ex. in water - swimming training (freestyle or breaststroke; for beginners-kicking) - including breathing ex.	• 6 wk • 3x/wk • 50 min	65% of the peak heart rate	• Nonchlorinated, outdoor • 26°C (95% CI: 24–28)
Weisgerber et al., 2008. USA	RCT	N = 45 (n = 17 golf group) Asthma	7–14	Swimming vs. golf	1:2 or 1:3 (certified instructors) • 30 min swim lessons • 30 min vigorous swimming: 4 phases-interval training (12–15 min periods), endurance training (continuous exertion), relay races (5–7 min), bobbing, water games (5–10 min); water polo or basketball	• 9 wk • 3x/wk • 60 min	High (8–10 METs)	N/R

(continued)



Table 4 (continued)

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Weisgerber et al., 2003, USA	RCT	N = 8 (n = 3 con. gr.) Asthma	7–12	Swimming lessons	N/R (certified swim lesson instructors) • beginner swim, (safety skills, front crawl, floating, lifejacket use), n = 3 • advanced beginner (learn endurance swimming, rotary breathing, elementary back-stroke, bobbing, treading), n = 2	• 5 to 6-wk • 2x/wk • 45 min	N/R	N/R
Hildenbrand et al., 2010 USA	Before -after study	N = 16 Asthma	Mean age 22 (SD 5.27)	Aquatic exercise progression (not requiring swim skills)	Group, 2:16 (certified aquatic instructors**) • w/u 10 min – conditioning 10 → 30 min – c/d 5 min • large, low impact, rhythmic movements, pre-stretching, cardiorespiratory ex. • vertical ex. in deep and shallow water (running, jumping, skiing, etc.) • games, stretching, breathing ex.	• 12 wk • 3x/wk • ↑ from 30–45 min (conditioning wk.1 = 15 min; wk.2–3 = 20 min; wk.8–12 = 30 min)	4–8 (aquatic RPE)	• Indoor • 25 yd/23 m • Depth 4'–9' 1.2–2.7 m • 29–30°C

N = sample size (participants that completed study); P = pathology; MPAA = moderate persistent atopic asthma; N/R = not reported; RPE = rating of perceived exertion; ex. = exercise; w/u = warm up; c/d = cool down; con.gr. = control group.

\*\*certifications from the Aquatic Exercise Association, Arthritis Foundation Water Exercise program, and American Red Cross Water Safety programs

studies (Hildenbrand et al., 2010; Wang & Hung, 2009).

3. **Diseases of the Circulatory System ( $N = 0$ ).** No publications were found for this group.
4. **Diseases and Disabilities of the Musculoskeletal System and Connective Tissue ( $N = 3$ ).** As can be seen from Tables 1 and 5, two of the intervention studies were RCTs. The total number of participants was 136 ( $N = 10$ –72 per study), ages 4–19 years. All studied youth with juvenile idiopathic arthritis (JIA).

*Intervention programs (Table 5).* Aquatic intervention types were group aquatic training (swimming and exercises in the water; Takken, Van Der Net, & Helders, 2001; Takken, van der Net, Kuis, & Helders, 2003) and a combined aquatic and land-based training (Epps et al., 2005) with a duration of 10–20 weeks, 1–2 times a week, and 30–60 min per session. Average total duration was 937 min with a range of 712–1,200 min. In two studies, the swimming pools were located in multiple centers, but detailed information was lacking.

5. **Mental and Behavioral Disorders ( $N = 15$ ).** Six articles had evidence levels I and II, but more than half had only levels IV and V. There were 174 participants ( $N = 1$ –42), ages 3–17 years. Nine intervention studies included children with an autism spectrum disorder (ASD).

*Intervention programs (Table 6a, 6b).* Five studies used the Halliwick Concept (Bumin, Uyanik, Yilmaz, Kayihan, & Topcu, 2003; Chu & Pan, 2012; Hillier, McIntyre, & Plummer, 2010; Yilmaz, Konukman, Birkan, Ozen, et al., 2010; Yilmaz, Yanardag, Birkan, & Bumin, 2004) and three studies reported swimming as the main intervention (Casey, Rasmussen, Mackenzie, & Glenn, 2010; Oh, Licari, Lay, & Blanksby, 2011; Rogers, Hemmeter, & Wolery, 2010). Three studies implemented a combined program of exercises in water and swimming (Fragala-Pinkham, Haley, & O’Neil, 2011; Pan, 2010; Yilmaz et al., 2009), and in four studies exercises in water and games were the main content (Ennis, 2011; Pan, 2011; Yilmaz, Birkan, Konukman, & Erkan, 2005; Yilmaz, Konukman, Birkan, & Yanardag, 2010). In addition, in five of these studies the actual focus was on the teaching method (teaching aquatic play skills and basic swimming skills) rather than the content (Oh et al., 2011; Rogers et al., 2010; Yilmaz et al., 2005; Yilmaz, Konukman, Birkan, Ozen, et al., 2010; Yilmaz, Konukman, Birkan, & Yanardag, 2010). Program duration ranged from 6–16 weeks, 1–3 times a week, and 30–90 min per session. Average total duration of the intervention program was 1,193 min and ranged from 210 to 2,880 min. Swimming pool description was provided in 11 articles. Two of these studies only provided a short description—“busy pool environment” (Hillier et al., 2010) and “cool water pool” (Fragala-Pinkham et al., 2011)—without specifications.

6. **Endocrine, Nutritional, and Metabolic Diseases ( $N = 3$ ).** The highest level of evidence was found in a nonRCT. The total number of participants for this group was 211 (15–149 per group), ages 7–19 years. The pathologies present in these studies were obesity and type 1 diabetes.

*Intervention programs (Table 7).* The aquatic intervention types used were swimming training sessions, water games, and activities. However, in two

Table 5 Diseases and Disabilities of the Musculoskeletal System and Connective Tissue With Intervention Details

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Epps et al., 2005, UK	RCT	N = 72 (n = 36 combin. gr.; N = 36 land gr.), JIA	4–19	Combination of hydrotherapy and land-based physiotherapy (combined group)	1:1 & group sessions (physiotherapists) • first 2 wk both groups: 16 one-hour treatment sessions • 2 months local physiotherapy • standard hydrotherapy ex. including stretches and strengthening ex. (stage 1–3) - upper limbs, lower limbs, trunk • general aerobic ex. (games, leg, arm movements according to ability) • simulated or real function ability (supine to sitting and vice versa)	Total 10 wk • Combined gr- 2 wk, 8 x 60-min hydrotherapy and 8 x 60-min land-based physiotherapy • 1x per 1 or 2 wk, over 2 months hydrotherapy only • 29 min (mean)	N/R	• Multicenter setting (3 centers) • N/R
Takken et al., 2003, Netherlands	RCT	N = 54; (n = 27 control group) JIA	5–13	Aquatic aerobic group physiotherapy training exercise program	Group, 1:2–4 (PT) • w/u - aerobic conditioning - rest – 2nd conditioning – c/d • rest and c/d periods: low intensity swimming, aquarobics, play, flexibility ex. or ball games • conditioning: mainly high intensity swimming, diving, walking through water, aqua jogging or splashing with legs	Within 6 months • 1x/wk, • 60 min (approx. 20 sessions)	HR measured. Duration and intensity of both conditioning parts ↑ stepwise	• Multicenter setting (20 different locations) • 30–33°C

(continued)

Table 5 (continued)

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Takken, Van Der Net, & Helders, 2001. Netherlands	Before-after study (pilot)	N = 10 JIA	5–12	Aerobic aquatic training program	Group, 1:2–4 (supervised by a pediatric PT) and an exercise physiologist • w/u - conditioning - short rest – conditioning - c/d • low intensity swimming, aquarobics, play, flexibility ex. or ball games (also rest and cooling periods) • conditioning: mainly high intensity swimming, diving, walking through the water, aqua jogging, or splashing with legs	• 15 wk • 1x/wk • 60 min	HR measured. Duration and intensity of both conditioning parts ↑ stepwise	• N/R • 32°C

N = sample size (participants that completed study); P = pathology; PT = physical therapist; N/R = not reported; ex. = exercise; w/u = warm up; c/d = cool down; JIA = juvenile idiopathic arthritis; combin. gr. = combined group; ↑ = increase

Table 6a Mental and Behavioral Disorders With Intervention Details.

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Oh et al., 2011. Australia.	RCT	N = 17 (DCD, n = 8; DCD-I, n = 9)	5–9	Swimming (on teaching methods)	Group, 1:3 (teachers with at least 2 years aquatic experience) • swimming techniques (front crawl, back-stroke) • the part-part-whole teaching method (motor tasks) • tactile instruction and feedback - before and at the end of each lap completed Individual, 1:1 (PT) • principles of the Haliwick Concept • graded task-specific training (ball skills, standing balance, walking/running) • principles of motor learning and mastery • concept of water specific therapy (WST)	• 10 wk • 1x/wk • 30 min	N/R	• Covered • 25 × 11 m • Stand on bottom • 28–29°C
Hillier et al., 2010. Australia.	RCT (pilot)	N = 12 (n = 6 con.gr.) DCD	5–8	Aquatic (physio) therapy program		• 6–8 wk • 1x/wk • 30 min	N/R	• Busy pool environment • N/R
Chu & Pan, 2012. Taiwan	non-RCT	N = 42 (n = 14 con.gr.) ASD	7–12	Haliwick Concept	Individual & group, 1:1 (aquatic instructors with undergraduate degree in PE; trained peers/siblings) • w/u 10 min – 1:1 instruction 35 min – group games & c/d 15 min	• 16 wk • 2x/wk • 60 min	N/R	• Indoor hydrotherapy and swim • N/R

(continued)

Table 6a (continued)

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Fragala-Pinkham et al., 2011. USA	non-RCT (pilot)	N = 12 (n = 5 con.gr.) ASD	6–12	Group aquatic exercise program	Group, 1:2 (YMCA aquatic staff, paediatric PT) • w/u - aerobic activities 20–30 min - training 5–10 min - c/d 5 min • shallow end activities – swimming laps, obstacles, games - strengthening & endurance activities - slow pace activities, stretching	• 14 wk • 2x/wk • 40 min	Planned 50–70% of max HR (moderate to vigorous), but it was lower	• Cool water pool • N/R
Pan, 2011. Taiwan	non-RCT	N = 30 (n = 15 no disab.) ASD	7–12	Aquatic intervention	Group, 1:1 (trained instructors) • w/u 10 min - individual/in pairs 35 min - group games 15 min –c/d 10 min • social and floor activities - (structured teaching (including visual schedules and work systems) - group game/activities	• 14 wk • 2x/wk • 60 min	N/R	• Indoor hydrotherapy and swim • N/R

(continued)

Table 6a (continued)

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Pan, 2010. Taiwan	non-RCT	N = 16 (n = 8 con.gr.) ASD	6–9	Water exercise swimming program (WESP)	Group, 1:2 (swimming instructors) • w/u 20 min - instruction 40 min – games 20 min – c/d 10 min • social and floor activities - 1:2 small group, water orientation, breathing, floating skills, stroke skills - whole group games –questions, rewards	• 10 wk • 2x/wk • 90 min	N/R	• Indoor hydrotherapy and swim • N/R
Casey et al., 2011. Canada	before-after study	N = 8 ID, fat levels (11–35%)	9–17	Swimming training program	Individual, 1-2:1 (2 qualified swim coaches, 1 APA specialist, 1 exercise physiologist, 9 researchers) • focus on the crawl stroke performance - ex. with the assistance of a flutter board. The volume of swim training gradually ↑ (200–1,000 m). 1–2 rest breaks (1–2 min). Aerobic tasks, velocity training	• 16 wk • 3x/wk • 60 min	60–80% of theoretic max HR	• Indoor • 25 m • 25.5°C (78°F)

N = sample size (participants that completed study); P = pathology; PT = physical therapist; N/R = not reported; ex. = exercise; w/u = warm up; c/d = cool down; DCD = developmental coordination disorder; DCD-t = tactile group; ASD = autism spectrum disorders; MR = mental retardation; disab.= disability; CTD = constant time delay

Table 6b Mental and Behavioral Disorders With Intervention Details

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Ennis, 2011, USA	Before-after study	N = 6 ASD	3–9	Aquatic program	Individual, 1:1 (PTs, doctoral students) • w/u 5-10 min – swimming, pull with hoop 5min - respiratory activities, pulling 5min - ball toss, reciprocal activity 5min • walking, floating, pulling through water 5min - jumping, push-off activities 5 min-mat/balance activities - diving under water (if able) 5min - free play 10 min	• 10 wk • 1x/wk • 60 min	N/R	• Therapeutic • N/R
Yilmaz et al., 2009, Turkey	Before-after study	N = 16 MR	12–15	Water exercises and swimming	Group, 6:16 (under directions of 3 physical therapy specialists and 3 swimming trainers) • w/u 10 min - 25 min - c/d 5 min • water ex. & swim drills (leg kicks, shoulder ex., leg strokes, hoop in the water, hip ex., free style swim. with standing position)	• 10 wk • 2x/wk • 40 min	N/R	N/R
Yilmaz et al., 2005, Turkey	Before-after study	N = 4 ASD	7–9	Aquatic play skills (CTD procedures)	Individual, 1:1 (researchers with special education) • probe, maintenance, generalization sessions • aquatic play skills using a 4 s constant time delay procedure • fun activities together. Instruction and intervention individually	• 10 wk • 3x/wk • 60 min	N/R	• Indoor • N/R

(continued)



Table 6b (continued)

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Yilmaz, Konukman, Birkan, Ozen, et al., 2010. Turkey	Case series	N = 3 ASD	8-9	Teaching swimming (CTD proc.)	Individual, 1:1 (special education researchers) • Halliwick Concept of swimming rotation skills • fun water activities (jumping, splashing, walking hand by hand)	• 10 wk • 3x/wk • 60 min	N/R	N/R
Yilmaz, Konukman, Birkan, & Yanardag, 2010. Turkey	Case series	N = 3 ASD	9	Teaching swimming skills	Individual, 1:1 (3 researchers in special education & physical therapy) • fun water activities with instructors • individual instruction and intervention • probe, maintenance, and generalization sessions • social reinforces (free time game activities, jumping up ward)	• 10 wk • 3x/wk • 60 min	N/R	• University indoor • N/R

(continued)

Table 6b (continued)

Reference and Country	Study Design	Sample Size	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Rogers, Hemmeter & Wolery, 2010. USA	Case series	N = 3 ASD, PDD-NOS	4-5	Teaching basic swimming skills (using CTD proc.)	Individual, 1:1 (graduate student, swimming teacher) • w/u 5 min • target - flutter kick, front-crawl arm strokes, head turns • each probe session 12 trials (4 trials per skill), embedded in aquatic play • 8 instructional trials with a 30- 60-s inter-trial interval	• N/R (33 sessions) • 2-3x/wk • 45-60 min	N/R	• Indoor • 22.86 m • Depth 0.91 m • N/R
Yilmaz et al., 2004. Turkey	Case study	N = 1 ASD	9	Halliwick method	N/R	• 10 wk • 3x/wk • 60 min	N/R	N/R
Bumin et al., 2003. Turkey	Case study	N = 1 Rett, stage III	11	Halliwick method	Individual 1:1 (physiotherapist) Halliwick method as the application of hydrotherapy 4 phases: adjustment to water; rotations; control of movement in water; movement in water	• 8 wk • 2x/wk • N/R	N/R	N/R

N = sample size (participants that completed study); P = pathology; w/u = warm up; c/d = cool down; ID = intellectual disability; ASD = autism spectrum disorders; PDD-NOS = pervasive developmental disorder-not otherwise specified; CTD proc. = constant time delay procedures

studies these categories were complemented by folk dance and soccer (Ildiko et al., 2007) and other indoor and outdoor activities (Klijn, Van der Baan-Slootweg, & Van Stel, 2007). Program duration was 12–35 weeks, 1–2 times a week, and 45–60 min per session. Average total duration was 1,292 min and ranged from 516–2,100 min. Swimming pool description was not reported in two articles.

7. **Sensory System/Integration Deficits ( $N = 0$ ).** No intervention studies were found in this group. However, some articles from the Mixed group include participants with sensory system and integration deficits (McManus & Kotelchuck, 2007) and children with visual impairments (Fragala-Pinkham et al., 2008).
8. **Congenital Malformations, Deformations, and Chromosomal Abnormalities ( $N = 0$ ).** No articles were found in the literature search. However, some disorders (e.g., chromosomal anomaly, oto-palatal-digital syndrome, Prader-Willi syndrome, Down syndrome) were included in other studies of the Mixed group (Fragala-Pinkham et al., 2009; Fragala-Pinkham et al., 2008; Fragala-Pinkham et al., 2010; McManus & Kotelchuck, 2007).
9. **Mixed Disabilities group ( $N = 4$ ).** One article was a nonRCT and others had evidence levels IV and V. In total there were 73 participants (4–37 per group), ages 6 months–19 years. The included pathologies are shown in Table 8.

*Intervention programs (Table 8).* Main intervention types were aerobic aquatic exercise programs (Fragala-Pinkham et al., 2008; Fragala-Pinkham et al., 2010) and combined aquatic and land-based therapy programs (Fragala-Pinkham et al., 2009; McManus & Kotelchuck, 2007). Program duration was 6–36 weeks, 1–5 times a week, and 30–60 min per session. Average total duration of the intervention program was 1,230 min with a range of 1,080–1,462 min. Pool description was provided in all articles.

## Discussion

The purpose of this study was to examine the levels of evidence existing on aquatic and swimming interventions for children with disabilities and to quantify and summarize the various aquatic interventions applied. An attempt was made to create a schematic overview on the existing research of aquatic and swimming interventions in children with disabilities.

The largest number of intervention studies was available from two groups, Neuro ( $N = 15$ ) and Mental ( $N = 15$ ). Interestingly, in both groups there were large proportions of before-after studies and single-subject research designs. Research designs of high evidence levels were found in the Resp group ( $N = 5$  in total;  $N = 4$  RCTs), as well as in the Musculo group ( $N = 3$  in total;  $N = 2$  RCTs). There is a higher homogeneity within these populations so that larger sample sizes and thus stronger study designs can be used.

Our results show that aquatic interventions are rarely investigated in children with sensory system and integration deficits, circulatory system problems, and congenital malformations and chromosomal abnormalities. This might be due to

Table 7 Endocrine, Nutritional, and Metabolic Diseases With Intervention Details

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Sideravičiūtė et al., 2006. Lithuania	Non-RCT	N = 47 (n = 19 T1DM; n = 28 healthy girls)	14-19	Swimming training sessions	Group, (N/R) <ul style="list-style-type: none"><li>• aquatic ex. 15–20 min – breaststroke and crawl 30 min</li><li>• at the beginning short swimming distances (up to 200 m) with the breaks, which later increased to 400 m with short breaks</li></ul>	<ul style="list-style-type: none"><li>• 14 wk</li><li>• 2x/wk</li><li>• 45 min (total 28 trainings)</li></ul>	<ul style="list-style-type: none"><li>• HR aimed to be not higher than 144–156 beats/min</li></ul>	<ul style="list-style-type: none"><li>• 25 m</li><li>• N/R</li></ul>
Ildikó et al., 2007. Hungary	Case-control study	N = 149 (con. gr:n = 43; con. gr:n = 75) obesity	7	Swimming and water games, folk dance and soccer	Group, (PE teacher) <ul style="list-style-type: none"><li>• swimming and water games (once a week)</li><li>• folk dance and soccer</li><li>• 60 min duration on separate days</li><li>• info about the risks of being overweight and the expected benefits of the exercise program (child psychologist 10 times during 10-month period)</li></ul>	<ul style="list-style-type: none"><li>• 35 wk</li><li>• swimming 1x/wk</li><li>• 60 min (+2 other extra-curricular activity sessions a week, 60 min)</li></ul>	<ul style="list-style-type: none"><li>• N/R</li></ul>	<ul style="list-style-type: none"><li>• N/R</li></ul>

Table 7 (continued)

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Klijn, Van der Baan-Slootweg, & Van Stel, 2007.  Netherlands	Before-after study	N = 15 obesity	10–18	Swimming activities (1x/wk); other indoor, outdoor activities (2x/wk)	Group. (exercise therapist – PE teacher) • swim jogging (1 set; exercise period 30 min) • water polo ex (1–3 sets of 3–6 ex.); sports game: 12–15 min • aqua jogging/aqua fitness (1–2 sets of 4–6 ex.) • swimming lanes and games (1–2 sets of 3–4 ex.) • (style of swimming is free)	• 12 wk training • 1x/wk in swimming pool • 43 min (mean) (all training 12 wk, 3 times a wk, 30–60 min)	• Individual target HR. • The program starts with 50% HR max. (later ↑)	N/R

N = sample size (participants that completed study); P = pathology; N/R = not reported; PE = physical Education; ex. = exercise; T1DM = type I diabetes mellitus; con. gr. = control groups; HR = heart rate

Table 8 Mixed Disabilities Group With Intervention Details

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
McManus & Kotelchuck, 2007. USA	Non-RCT	N = 37 (con.gr. n=22) (delayed funct. mob.)	6 mo-30 mo	Combined aquatic and land-based therapy program	Individual, 1:1 (occupational therapist and PT) • standing play, gait training, kneeling, squatting, dynamic balance activities on floating mats, stepping activities with underwater bench, and resistive play with weighted toys and water currents	• 36 wk • 1x/wk • 30 min	N/R	• Pediatric pool • 9.2 x 4.5 m • Depth 0.3–0.6 m • 31.6°C (89°F)
Fragala-Pinkham, O'Neil, & Haley, 2010. USA	Before-after study, summative evaluation	N=16 ASD & CP	6–12	Aquatic exercise	Group, 1:2 (physical therapy students, supervised by pediatric PT) • w/u 3–5 min - aerobic conditioning 20–30 min - strengthening ex. 5–10 min – c/d 3–5 min • lap swim, relay races, obstacle courses, water basketball games • arm and leg exercises (barbells, noodles, water resistance) • slow activities, shoulder, leg, trunk stretching ex.	• 14 wk • 2x/wk • 45 min	50–70% of HR max. HR range = 135–160 beats/min	1) Depth ~ 1–1.4 m /n = 9/1, 30.5°C (87°F) 2) Depth ~0.9 m –3 m /n = 7/1, 27.5°C (82°F)
Fragala-Pinkham, Haley, & O'Neil, 2008. USA	Before-after study	N = 16 (ASD, PDD-NOS, ADD, MMC, Down, CP, Visual, etc.)	6–11	Group aquatic aerobic exercise program	Group, 1:2 (physical therapy students or aquatic staff, supervised by pediatric PT) • w/u 3–5 min - aerobic ex. 20 min - strength training 5–10 min – c/d 3–5 min • lap swim, relay races, games with a focus of maintaining a defined target HR zone • ex. using bar bells, aquatic noodles and water resistance • stretching	• 14 wk • 2x/wk • 40 min	Focus on maintaining a defined target HR zone	• Two community pool sites • N/R

(continued)

Table 8 (continued)

Reference and Country	Study Design	Sample Size and P	Age (y)	Intervention	Group vs. Individual; N Teacher : N Kids (Type of Instructor); and Program Details	Duration	Intensity	Pool Description, Water Temperature
Fragala-Pinkham et al., 2009. USA	Case series	N = 4 (CP, JIA, Prader-Willi Syndrome)	N1:2; N2:7; N3:10; N4:19	Aquatic and land-based physical therapy intervention	Individual, 1:1 (PT) 50% or more of the physical therapy sessions in the pool CASE1: squat to stand (50% WB - ↑75% WB) - gait training on underwater treadmill, shuttle running - jumping in place, step ups, walking into the jets (50%WB)- active/passive ROM in warm tub CASE2: balance activities - gait training on treadmill - running/sprinting on underwater treadmill - swimming above and under water against jets CASE3: strength training - bilateral leg ex. - standing and sitting balance ex. (resistance form jets) - gait training - cardiorespiratory endurance activities CASE4: static stance with bilateral upper extremity support and water chest deep - sit to stand activities using pool wheelchair - step-ups (WB 25%)	CASE1: 6mo, 1/wk, 45-60 min; CASE2: 6wk, 2 /wk, 60min CASE3: 10wk, 2/wk, 60min+ 22wk, 1/wk, 60 min; CASE4: 6wk, 5/wk, 45 min	N/R	• Therapeutic/hospital • 2.4 x 3.6 m; • Adjustable depth • N/R

N = sample size (participants that completed study); P = pathology; delayed functional mobility = delayed functional mobility (CP, muscular myopathy, sensorimotor deficits); ASD – autism spectrum disorder; CP = cerebral palsy; PDD-NOS = pervasive developmental disorder not otherwise specified; ADD = attention deficit disorder; MMC = myelomeningocele; JIA = juvenile idiopathic arthritis; PT = physical therapist; N/R = not reported; ex. = exercise; w/u = warm up; c/d = cool down; WB = weight bearing; mo = months

lower prevalence rates and the manifestations and ability levels even within the same diagnosis might differ widely.

In the groups with the largest amount of intervention studies, only six (four in the Neuro and two in the Mental group) included more than 20 participants (Aidar et al., 2007; Chu & Pan, 2012; Dimitrijević et al., 2012; Getz et al., 2007; Özer et al., 2007; Pan, 2011). The small sample sizes can be partly explained by the heterogeneity of these populations as it includes a wide range of different ability levels and activity limitations. On the contrary, larger sample sizes were observed elsewhere, for example, 149 and 72 participants for the populations children with obesity (Ildiko et al., 2007) and JIA (Epps et al., 2005), respectively. In addition, the prevalence of obesity among children has increased in the last years.

## Intervention Programs

We intended to quantify the various aquatic and swimming interventions in several categories. This was challenging as no common guidelines and definitions for the different interventions are available. In addition, as Table 2 shows, various intervention types were used within one program. Furthermore the proportion of each component was not always stated. Unfortunately, 6 of the 45 intervention studies did not report any details of the intervention program. In most cases aquatic activity programs were individualized according to each participant's unique therapy goals, incorporating several techniques and components, as can be seen in Tables 3–8. This might be a reason why interventions were not well described, as the individualized programs may be difficult to explain to the reader, and the space provided by the journal editors may be too limited.

In the Mental group in five studies, the actual focus was on the teaching method (teaching aquatic play skills and basic swimming skills) rather than the content. Three of these studies tried to examine the effectiveness of the “constant time delay” procedures on simple aquatic skills of children with ASD and Pervasive developmental disorder not otherwise specified (Rogers et al., 2010; Yilmaz et al., 2005; Yilmaz, Konukman, Birkan, Ozen, et al., 2010).

Important to note is that most of the studies (68%) did not report the training intensity of the intervention. Results showed that only 2 of the 15 studies in the Mental and 3 of the 15 studies in the Neuro group reported the training intensity (four studies measured heart rate [HR]; one used OMNI rating of perceived exertion [RPE]). For the children with JIA, the intensity was reported in two out of three articles (HR) and for the children with asthma in three out of five articles (RPE; HR; metabolic equivalent of task or the rate of energy consumption). In addition to the low reporting rate, it must be noted that the planned intensity is not always achievable. Fragala-Pinkham et al. (2011) reported that their intensity was aimed at 50–70% of max HR, but in reality this was lower. A reason for not reporting the training intensity might be the lack of practical and reliable tools to measure the intensity in a water specific environment in this population. RPE is a subjective measurement; HR during submersion differs from that on land (Becker, 2009) and HR monitors might not always work under water, especially because children are usually more active and may not keep it in place; and METs are of indicative values only as 1 MET was originally developed as an adult value (Nilsson, 2008). In addition, a measure of an individual's resting oxygen uptake is necessary to calculate



METs more precisely; and even though the oxygen uptake is expressed relative to body weight, the baseline value of 3.5 ml O<sub>2</sub>/kg/min is only an approximate average value for sitting at rest (Jetté, Sidney, & Blümchen, 1990). Without training intensity reported, it is difficult for practitioners and researchers to replicate the interventions. Besides intensity, program duration and frequency have a considerable impact and were reported in all articles with few exceptions. Overall, the duration of interventions examined in this paper ranged from 5–36 weeks (not less than 10 weeks in patients with JIA, obesity and Type 1 diabetes), 1–3 times a week (with the exception of one adolescent with Prader-Willi syndrome in the Mixed group, participating 5 times a week). Usual duration per session was 30–60 min, except for the Metabolic group, where exercises lasted a minimum of 45 min and for the Mental group, one study (Pan, 2010) exercised up to 90 min/session. The total duration of the programs ranged from an average of 937 min in the Musculo group to an average of 1,292 min in the Metabolic group.

Water temperature was reported in only 16 studies (36%), despite its relevance for rehabilitative issues (e.g., arthritis exercise). In children with JIA, two out of three articles reported temperatures ranging from 30°–33°C; although, for typical aquatic therapy, water temperature is recommended to be neutral (33.3°–35.5°C; Becker, 2009). These two studies included high intensity swimming which could have compensated for the lower water temperatures. In the Neuro group ( $N = 15$ ), the temperature of water was reported in seven articles (27.7°–34°C), which is considered to be cool to neutral (Becker, 2009). As water conducts cold much more than air, cooler water may not be suitable for people with more severe disabilities, because they are usually less active. On the other hand, children generally tolerate cooler water temperatures after an initial warm up (Petersen, 2011). Considering the water temperature, aquatic professionals should consider the type of disability, intensity, and duration of the exercise. However, in reality, pool availability is an issue, as not all communities have swimming pools with different temperatures and adjustable depth (so called purpose-built pools).

To conclude, the categorization of the aquatic interventions was difficult due to several problems: The lack of common definitions, the absence of intervention program details, an undefined mix of several intervention categories, individualized therapy or training plans without a decision-making model, the absence of training intensity, and different types of pools (temperature and depth). This makes it difficult for researchers and practitioners to apply the interventions to achieve the same goals.

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